Bringing the Customer to The Ship Designer

LPD 17's Virtual Crew

KENDALL KING

The ship's helmsman glances again at his helm console and compass, checks his magnetic Fluxgate compass, and then takes a momentary look up to find where the Officer of the Deck (OOD) is located. The OOD hovers near the centerline of the Pilot House using one of the Integrated Bridge System consoles to scan the radar picture while keeping an eye outside, dead ahead (Figure 1). Both watch standers are on the bridge of the *USS San Antonio* (LPD 17), the Navy's newest amphibious transport dock, as the helmsman continues the inspection.

Next, the helmsman looks right to view the Commanding Officer's chair, continues further right to check the chart table and ship's navigation area, swivels to view the Boatswain's Mate of the Watch's position, and then completes the pivot by viewing the port side of the bridge and the training console.

The interesting part of this scenario is not that LPD 17 has a daydreaming helmsman nor that he or she just turned their head around 360 degrees. Instead, what is truly innovative is that this scenario took place before beginning construction of the ship. In fact, actual Fleet Sailors were able to view the Pilot House design from the helmsman's console in an electronic 3D model. With the completed ship's delivery still three years away, these "Virtual Crewmembers" reviewed, revised, and then validated a Pilot House that they will not physically enter until the year 2003. This is the LPD 17 Program's Virtual Crew process where the customer is brought to the ship designer.

Artist rendition of an LPD 17 class ship launching an Evolved Sea Sparrow Missile while operating in the littoral. Current planning has reserved space and weight for the Vertical Launch System Only.

LPD 17 Program Fundamentals

In designing the first amphibious ship of the new millennium, the LPD 17 program faced formidable objectives. Primarily, the ship class needed to satisfy its customers, the Navy and Marine Corps team, who must accomplish a variety of expeditionary warfare missions within changing national strategies, against diverse threats, while keeping costs down. To help meet this objective, TEAM 17 (Litton/Avondale Industries, Bath Iron Works, Raytheon Systems Company, and Intergraph Corporation) fully embraced the tenets of Integrated Product and Process Development (IPPD).[1]

In 1995, Secretary of Defense William Perry stated that IPPD "can enhance our ability to provide what the warfighter needs, when needed, and at a cost that the Department can afford."[2] For LPD 17, using IPPD created an environment where the best government and industry practices coalesce into timely decisions and optimal processes. These will ultimately lead to a product that fully serves the customer's requirements.

King *is a retired Navy captain and senior analyst with American Systems Corporation. He has supported the Design for Ownership process since 1996 and now facilitates the Virtual Crew for PMS 317. During his naval career, he commanded the* USS Fresno, *LST 1182. A 1971 graduate of Clarion University of Pennsylvania, King holds advanced degrees from American, Golden Gate, and Old Dominion Universities.*

U.S. Navy images/illustrations unless noted otherwise

In the words of John McIntire, government leader of the LPD 17 Total Ship Engineering Team, "In shipbuilding, the majority of the issues are process-related. There are many technical experts among the government and industry who can be correcting and redirecting process to prevent problems rather than fixing the product. 'After the fact' is too late." With IPPD in hand, and a full understanding of the program's objectives, TEAM 17 set about creating a revolutionary design for the Fleet.

Design for Ownership

A key element in IPPD is customer focus. In fact the first paragraph of the first chapter of the *DoD Guide to IPPD* spells out its importance: "The primary objective of IPPD is to identify and satisfy the customer's needs better, faster, and cheaper. The customer's needs should determine the nature of the product and its associated processes."[3] For TEAM 17, the customer is the Sailor who will crew LPD 17 and the Marine who will embark in the ship for the next 40-50 years.

Fleet Sailors have traditionally been involved in designing Navy ships, but often that participation occurred only at key milestones. Borrowing an approach from the Boeing 777 effort, the LPD 17 team established the Design for Ownership (DFO) process where involvement is established early and sustained throughout the design development. By soliciting Fleet and Marine ideas, suggestions, and recommendations at various stages in design, the program captured such benefits as:

- Reduction in initial cost and late, expensive changes.
- Assurance that Ship/Systems will be delivered combat-ready.
- Avoidance of surprises when Precomm Crew arrives and first Landing Force embarks.

Since mid-1995, LPD 17's DFO process has brought together the warfighter, operator, maintainer, and trainer into the design, test, construction, logistics, and life cycle planning efforts inherent in the Integrated Process and Product Development (IPPD) approach. Our DFO Team collected Fleet and Marine Corps recommendations, passed them to appropriate TEAM 17 IPTs, and then documented the outcomes. In some instances these suggestions entered LPD 17 class design, while other inputs provided added justification to enable improvements (and added funding) or were incorporated into planning for LPD 18.

Still other DFO data contributed "general consideration" items that influenced non-design criteria such as in manning or training. Finally, certain issues were not incorporated into design and were documented for historical record, followed by a response generated as feedback to the originator (Figure 2).

The DFO process relied upon a series of workshops and face-to-face events with TEAM 17. In over 50 separate meetings, Fleet and Marine Corps attendees participated in a variety of activities such as reviewing mission and capabilities, identifying maintenance and training concerns, modifying/reviewing medical and dental space design, revamping spaces to improve process, or developing a revised ship's organization.

Flag and general officers to hospital corpsman and gunnery sergeants have played a role in these sessions. In one example, part of the Navy/Marine Corps team that rescued Air Force Capt. Scott O'Grady from Bosnia in 1995 returned to contribute their lessons learned to the design review of the LPD 17's Combat Information Center and Troop Operations and Logistics Center. In another example, we adopted the pots and pans washer recommended by a second class petty officer.

To date, we have capitalized on the 1,400 individual issues received from Sailors and Marines, and over 200 ideas have directly led to design changes so far. However, to maintain our customer focus we evolved DFO into the next step – the Virtual Crew.

Virtual Crew

Unit Readiness Reviews (URR) are critical milestones in the LPD 17 program. "Units" are the basic building blocks of the ship, consisting of adjacent ship spaces with supporting distributive systems. LPD 17 consists of 211 units. During each URR, the Alliance will present its detailed design to the government for review and for the approval to begin production. To help with the preparations, the Alliance asked for Sailors and Marines to join in their pre-URR design review process. These future customers became the Virtual Crew, and their impact relies upon a distinct organization and pattern of events to achieve success.

Virtual Crew Organization

Today, Virtual Crew consists of a core group of subject matter experts who may be called upon to provide specific expertise tailored to a specific need at the right time. Ideally, the Virtual Crew draws from the same specialists each time, but Fleet workload and operational tempo have priority. A session may not have the

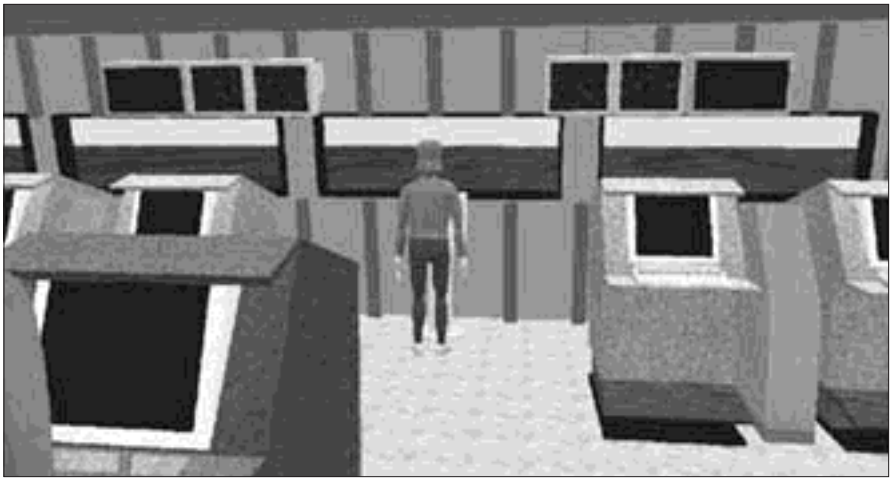


FIGURE 1. **Post-Review Design**

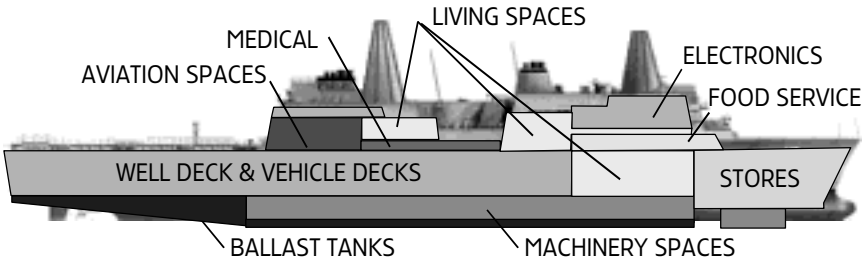


FIGURE 2. **Design for Ownership Brings Eventual Owner and Designer Together to Review Whole Ship**

same experts every time, but expanding the audience enhances the opportunity for fresh ideas.

Building upon the hundreds of Sailors and Marines who participated in various DFO events, we wanted to expand our baseline invitee list into the larger Virtual Crew pool of experts. As a recruiting initiative, program Master Chief Petty Officer Paul Chism visited both coasts to meet with commands, brief them on Virtual Crew, and then invite participation. His audience included the Amphibious Group staffs, Afloat Training Groups, Fleet Training Groups, and even the collective master chiefs in the Navy. With Marine Corps involvement assured from their previous longstanding DFO interest, the first series of reviews began in May 1999.

In its workup for URRs, the Alliance orchestrated a schedule of upcoming initial design reviews, 50-percent design reviews, and 90-percent design reviews of various ship zones (or units). Each relevant IPT such as Hull, Machinery, Interior Ships' Electronics, or Topside teams identified the zones where they desired Virtual Crew focus. A "zone" might include a single space such as the flight deck, upper vehicle stowage, or a series of miscellaneous spaces in adjacent areas. Each zone would show decks and bulkheads, furniture and equipment racks, and distributive systems such as ventilation, electrical, and firemain. The zone's detail would of course vary as the Alliance's design progressed.

To coordinate execution of the Virtual Crew, our government DFO Team transitioned their DFO experience to execute this process. The Team promulgates the Virtual Schedule two weeks in advance via E-mail and updates it weekly or even daily to keep pace with the dynamic design process. Team members also follow up to verify anticipated attendance and will sometimes seek additional participation.

For instance, in a recent Shore Power Control Station session, representatives from the Board of Inspection and Survey, a lead electrician from a naval base public works department, and a crane operator joined the Virtual Crew's electrical and engineer officers from the Amphibious Groups and Navy Safety Center to comment on design.

The DFO Team sends out readahead material, provides copies of previous relevant Virtual Crew action items, and distributes appropriate issues from the DFO lessons learned database to enhance participation. At each Virtual Crew session, they also help capture action items and then periodically disseminate the action taken to the Virtual Crewmembers in a feedback report.

Video Teleconferencing (VTC) facilities provide for connectivity among the design sites (Figure 3) and between the Virtual Crew and Design Teams. Using a Memorandum of Agreement established with the Commander of the Expeditionary Warfare Training Group Atlantic in Little Creek, Va., our program conducts business from a shared "LPD 17 War Room." West Coast participants connect via VTC at the headquarters for Commander, Amphibious Group Three.

Sequence of Events

A typical Virtual Crew session starts with a DFO Team member updating the crewmembers on the LPD 17 design. This ensures that all crewmembers start with an understanding of the ship and the Virtual Crew process. Next, the Alliance establishes VTC connectivity with all of the sites, and then the IPT Design Leader for that particular zone presents the ground rules. Typical ground rules for a Virtual Crew follow:

- Questions and comments are welcomed anytime during the event.
- Crewmembers signal the War Room Moderator (DFO Team) who unmutes "near end" so that the comment can be made (this reduces talkover interference).
- Crewmember confirms his or her identity, command, and location be-

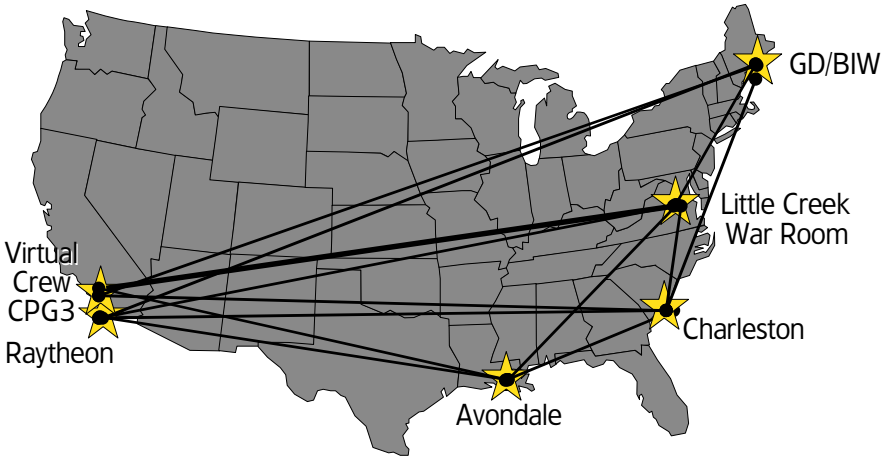


FIGURE 3. **Virtual Crew Sites Enable Sailor and Marine Direct Interaction With Ship Design Team**

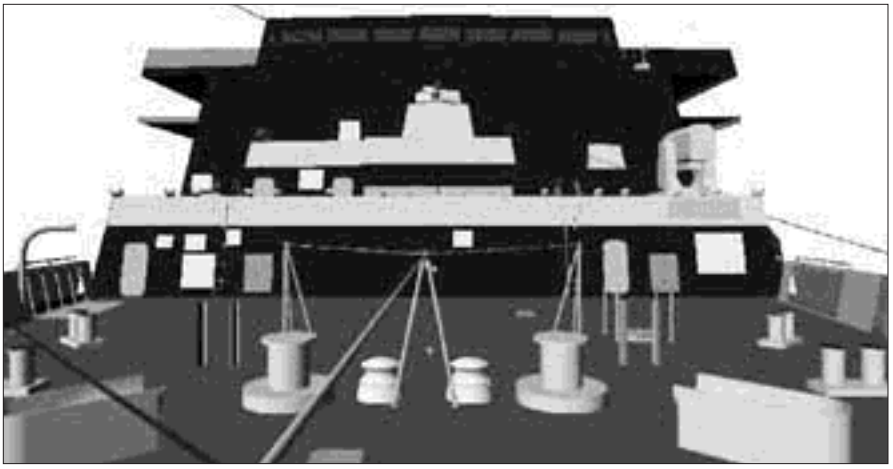


FIGURE 4. **Example of Ship's Foc'sle Used in Initial Design Review of Shore Power Control Stations**

fore asking a question or commenting.

- Crewmember asks a question or makes a recommendation. Important criteria for these inputs include: safety; the impact on the ship's ability to achieve required operational or combat readiness; potential for reduced Total Ownership Cost; and the possibility for improved quality of life.
- Action Item is captured, and then session moves on. Discussion may be limited, depending upon the amount of time allotted.
- Crewmember may request any view, may ask for dimensions, or may even ask for an anthropomorphic Sailor to "walk through" the design area.
- At the end of each session, Virtual Crew reviews action items from all sites.
- All suggestions and recommendations will be considered. They may not be adopted or may be referred to LPD 18 or beyond, but they are considered.

The IPT Design Leader then starts a zone overview using a PowerPoint presentation. The leader establishes the location of the space on the ship's profile, displays a two-dimensional drawing of the zone with the list of spaces included, and often portrays drawings of adjacent spaces both above and below the zone of interest.

Next, the leader guides the Virtual Crew through furnishings and equipment lists, reports the status of various field modification requests (impending design changes), and concludes with an estimate of the zone's progress. For instance, a 50-percent design review might include 100 percent of the structural aspect of the zone, 50 percent of the furnishings, and none of the firemain distributive system. (Figure 4 provides an example of the ship's foc'sle used in the initial design review of the Shore Power Control Stations.)

Next, the IPT Leader conveys the Virtual Crew through a three-dimensional electronic model of the zone using DENEB or IDR modeling.[4] Usually, the "walkthrough" starts from the top down for the entire zone and then focuses on an individual space. The viewer may be guided through the space from that top-down approach or allowed to enter through the space's door. Distributive systems such as lighting, may be removed to enhance the view or added to demonstrate a more realistic view. Equipment foundations may be viewed from the bottom up.

The review may also include a check on equipment maintenance envelopes such as a Sailor opening an equipment rack drawer. Overhead clearance, passageway clearance, or distances between bunks can also be measured. If a Virtual Crewmember requests a certain view, the computer model can portray that perspective, for example, from the helmsman's console in the Pilot House. Or the modeler can actually move an electronic Sailor or Marine throughout the compartment, validating ease of movement or visibility from the anthropomorphic 95-percent-sized male's or 5-percent-sized female's standpoint. Each of the other spaces in the zone is similarly reviewed until the zone is completed and all action items collected.

Typical Walkthrough

Review of LPD 17's Closed Circuit TV Control space provides a typical example of a Virtual Crew session. Both West and East Coast participated, including a first class journalist who operates a TV system on an amphibious ship. After the top-down review and during the walkthrough of the space, the petty officer noted that the Design Team had positioned the TV for monitoring picture

Capt. William H. Luebke, USN

LPD 17 Program Manager (PMS 317)

Capt. William H. Luebke has been the LPD 17 Program Manager (PMS 317) since 1997. Previously, he served as AEGIS Test Director for CG-47 Class Ships; Production Officer in PMS 400 (DDG-51 Class); Director of Surface Combatants, staff of the Assistant Secretary of the Navy (Research, Development and Acquisition); and Deputy Program Manager for Strategic Sealift Ships (PMS 385). Luebke is a 1975 U.S. Naval Academy graduate and holds advanced degrees from the Naval Postgraduate School and the Massachusetts Institute of Technology. He is a graduate of PMC 95-1, DSMC.

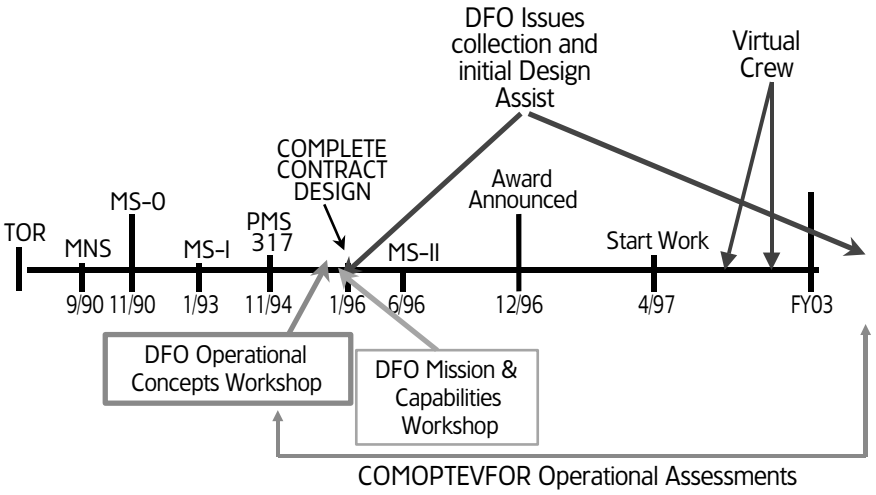


FIGURE 5. **The Earlier the Better for DFO and Virtual Crew**

quality where it could only be seen from the equipment racks (where he would go to adjust the system). This was good, but he also recommended placing the TV on a swivel or relocating the monitor so it could be viewed from the desk of the control room—where the TV system operator would spend the bulk of his or her time. The journalist also recommended deleting some of the furniture in the space to open more studio room, a relatively easy change at this stage in procurement.

Other members of the Virtual Crew discovered an equipment rack that interfered with a manhole cover opening to the next deck. Relocating the rack away from the cover as validated by the Virtual Crew becomes far less expensive for the Alliance to correct before steel is cut.

Other questions arose during the session that led to a recommendation to verify TV camera storage. The next day, a DFO team member accompanied the journalist to his ship and took digital pictures of the ship's more effective way of stowing the large studio camera. These pictures were then transmitted to the Design Team to help validate their planning and design.

Virtual Crew Results

So far, the LPD 17 program has hosted 70 Virtual Crew sessions with participation of over 600 individual Fleet and Marine Corps representatives. Although the initial plan defined only 65 high-interest spaces for target review sessions, the Virtual Crew has examined five times that number of spaces—from fan rooms to main engineering rooms. The IPTs have reaped the benefits of hundreds of comments; less than halfway through the review, 68 recommendations have thus far led to engineering changes.

This number may seem trivial, but if discovered after delivery these items could have led to safety concerns, reduced combat readiness, or just dissatisfaction with the ship's design. For example, in the Main Machinery Room a person exiting the space from the lower level had to go up a ladder, cross the upper level, and then leave the space from the other side. Relocating the ladders to the same side eased access and safety in case of a lower-level fire.

In another instance, the IPT relocated a Wet Sprinkling Pipe to clear a wireway in a Troop Living Space as noted by the Virtual Crew. Other incorporated changes have impacted boat operations, repair locker stowage, and even lack of compatibility between a welding shop and nearby fuel tanks. Indeed, Virtual Crew is making its mark on LPD 17.

Lessons Learned

Virtual Crew has not been a perfect process, and we are learning much as it matures. Even when discovered four years before delivery, changes have costs. Our change budget has gone further because we have identified many needed changes early. The Virtual Crew is also more work. The IPTs now must coordinate more formal design reviews, incur more comment, and sometimes endure more criticism, which increases workload as they improve design.

We also discovered that the Sailors and Marines—our ultimate customers—are very interested and committed to helping with the LPD 17 design. They appreciate being invited and appreciate helping to make a difference. Sometimes they do not understand why a certain change cannot be implemented, and this has led to focus groups on such topics as Motor Gasoline facilities, Navigation Lights, the Advanced Enclosed Mast/Sensor and Flag Display, and Shore Power Control Stations. These splinter groups created compromise and buy-in among the participants by expanding Virtual Crew sessions into actual day-long, face-to-face workshops. The Virtual Crew places a premium on busy Sailors' and Marines' time, but the LPD 17's program partnership would not succeed without their participation.

Both DFO and the Virtual Crew have made a difference, but their impact would have been even more significant earlier in the acquisition process. These processes should be implemented prior to the development of the Operational Requirements Document or at least as part of the Request for Proposal (RFP) development.

The first inputs that we received in 1995 and early 1996, although late in the actual acquisition process, were incorporated into the RFP at absolute minimal cost. A Virtual Crew review, even with some of the basic space computer models we had at the time, would also have helped (Figure 5). For example, in 1999 the Virtual Crew discovered a structural beam impacting visibility in the Pilot House that should have been eliminated from the design in 1995 when other structural changes were made.

Still, from the program manager's perspective, Virtual Crew adds real value. In the words of Navy Capt. William Luebke, LPD 17 Program Manager, "The

DFO process and Virtual Crew have helped avoid costs; are eliminating some of the late, potentially costly changes; and importantly, are helping to ensure customer acceptance and satisfaction with the first amphibious ship of the 21st century.

These tools are helping us achieve the primary objective of IPPD and are definitively keeping our focus on the customer. Best of all, in 2003, when that young Sailor steps up to the helm console or that officer takes the Conn in the LPD 17 Pilot House, they will not be surprised at what they see — they will appreciate that the LPD 17 Program Management Team brought the customer to the ship designer.

Editor's Note: The author and program manager welcome questions or comments on this article. Contact Luebke at **LuebkeWH@1lpd17.navsea.navy.mil**; contact King at **Kendall.King@2asc.com**.

ENDNOTES

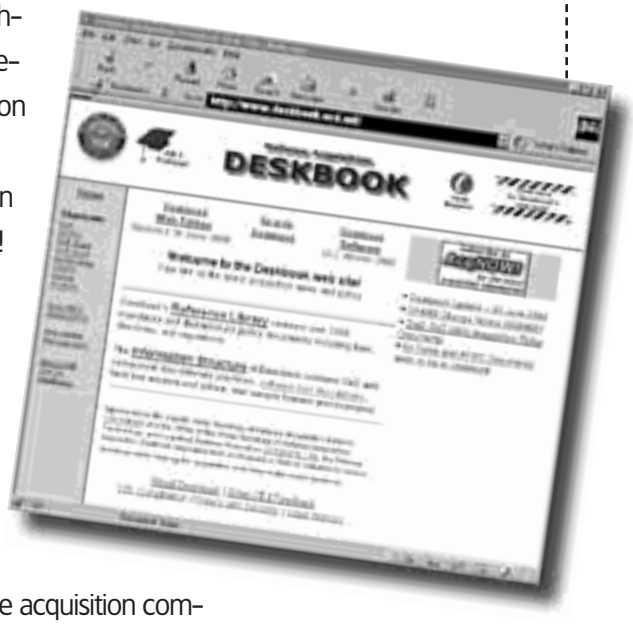
1. Team 17 consists of the government representatives, headed by the LPD 17 Program Office, PMS 317, and the primary industrial activities of the Avondale Alliance — Litton/Avondale Industries, Bath Iron Works (BIW), Raytheon Systems Company, and Intergraph Corporation. In the simplest division of labor, Litton/Avondale will build eight of the ships, BIW will build four of the ships, Raytheon will oversee total ship integration, and Intergraph will focus on development of the Integrated Product Data Environment.
2. Secretary of Defense Memorandum, May 10, 1995, "Use of Integrated Product and Process Development and Integrated Product Teams in DoD Acquisition."
3. *DoD Guide to IPPD*, Chapter 1, "IPPD Concepts." (The electronic media for the Guide may be downloaded from **www.acq.osd.mil/te/survey/tenets.html** on the Web.)
4. Software produced by DENEB and used by the majority of the Virtual Crews, which creates an interactive simulation from a 3D electronic model. This software allows for anthropomorphic ("Ergo people") Sailors to be placed in the model and to move about; permits visualizing a perspective from a certain position in the space; and has the ability to measure dimensions as requested. IDR, the Intergraph Design Review software, creates a 3D picture that can provide multi-views, but does not include the other DENEB features. Intergraph is used for initial design review in situations where all of the components (library parts) have not been configured or added into the computer model.

Inside DSMC

Navy Capt. Robert Vernon, Dean, School of Program Management Division (SPMD) departed the College June 18, 2000, for a new assignment as Professor of Naval Science and Commanding Officer of the Naval Reserve Officer Training Corps at the University of Oklahoma in Norman. Vernon has been the Dean of SPMD since his arrival at the College in June 1996. Upon his departure, he was awarded the Defense Superior Service Medal by Air Force Brig. Gen. Frank Anderson Jr., DSMC Commandant.

Acquisition Awards Link

With the establishment of the Defense Acquisition Deskbook Awards link, finding award information has now become easier!



The Office of the Under Secretary of Defense (Acquisition, Technology & Logistics) has developed a consolidated database of award programs available to the acquisition community.

The Deskbook database can be accessed from the Awards link at **http://www.deskbook.osd.mil**.